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HIGH STRENGTH CONCRETE BY PARTIAL REPLACEMENT OF CEMENT BY FLY ASH, METAKAOLIN AND ALCCOFINE

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Abstract – *Construction place an important role in the economic development of a country. For construction concrete is the main component, the elements of concrete includes cement, fine aggregate, coarse aggregate, water. As India is a developing country which is moving towards Urbanization, thus the Construction and Infrastructure place a main role therefore the demand for cement is increasing, but cement industry is producing more pollution as the demand is more. So, In order to reduce the pollution, here in this paper we are partially replacing cement by supplementary cementitious materials like Fly ash, Metakaolin(MK) and Alccofine (AF). IN this paper replacing cement by fly ash, MK and AF we have studied the strength properties of concrete.*

Key Words: **Alccofine(AF), Metakaolin(MK), Flyash Polypropylene fibres**.

1. INTRODUCTION

Now a days Constructional industries are demanding High strength Concrete along with good economy. So, partial replacement of cement has a good scope. In this paper as we are using pazzolanic material like flyash, MK and AF, we can expect high strength, durability and early strength.

Fly ash is a mineral admixtures and pozzolanic material which is obtained by combustion of powder coal and it is common ingredient in concrete, having less or no cementitious property but when it combines with water chemical reaction takes place to form additional C-S-H gel. Flyash reduces the Heat of Hydration and reduce the cost.

MK is an artificial pozzolanic material and it is not a by-product of any industrial processes nor it is entirely natural, it is obtained by natural mineral. MK has great promise as a supplementary cementitious material (SCM). MK is produced by heat-treating kaolin, one of the most abundant natural mineral.

AF is a specially processed mineral additive obtained by slag which is rich in glass content and it has capability of reducing water consumption. In AF there are two categories one is Alccofine 1200 and Alccofine 1101. In AF 1200, based on fineness there are 3 series 1201, 1202 and 1203. Here we are using AF1203 because of its Ultra fineness and its strength contribution.

Polypropylene has been recognized that addition of small closely spaced and uniformly dispersed fibres to concrete would act as crack arrest.

2. LITERATURE REVIEW

Yathin Patel, Dr. Smt. B.K. Shah and Prof. P.J Patel (2013) analyzed the Pozzolanic action is responsible for impermeability of concrete. They used AF 8% and Flyash 2% and got 54.89mpa for 28 days and 72.97 for 56 days. Due to smaller particle size voids get reduced so, indirectly helps in gaining the strength. AF due to its Ultra fineness has minimum loss of weight and minimum loss of compression strength because of its compactness and less permeability.

Malvika Gautam and Dr. Hemant sood (2017) analyzed that AF increase the compression strength of concrete of all age and AF increase the strength to larger extent up to 10% replacement, though the cost of AF is higher than cement it can be adjusted in construction field.

Mohammed samiuddin fazil and Fouzia shaheen (2015) analyzed that all the concrete mixes made with various replacement ratios of MK and AF by weight of cement shows more compression and flexural strength when compare to the ordinary concrete mix.10% replacement of AF gives higher flexural strength.

Alaa M. Rashad (2013) analyzed that 5% MK replacement exhibits optimum content with or without super plasticizer and 10% MK exhibits the optimum content in concrete with the inclusion of super plasticizer.

M.Narmatha and Dr. T. Felixkala (2016) analyzed that the strength of all MK concrete mixes over shoot the strength of OPC.15% replacement by MK is superior to all other mixes. The increase in MK content improves the compressive strength and split tensile strength.

Nova John (2013) concluded that partial replacement of cement by MK results in high compression, flexure and split tensile strength. The high strength achievement by replacement of cement by 15% MK ensures use of MK has supplementary cementitious material. Use of MK as supplementary cementitious material helps in solving environmental, technical and economic issues due to cement production.

2.1 AIM

Achieving high strength concrete by replacing cement by Metakaolin, Fly ash and Alccofine in optimum amount.

2.2 OBJECTIVE

From the literature reviews the objectives defined are as follows

- To get the high compressive strength by replacing cement by Flyash, Alccofine and Metakaolin at different proportions.
- To Improve strength properties and workability of the concrete.
- To Increase the pozzolana material proportions.
- To Reduce the cement content.
- To Reduce the Usage of Water.

2.3 MATERIALS

Cement:
Ordinary Portland cement of 53 grade is used in this project.

Manufactured sand (M-sand):
Zone 2 grade of locally available sand of passing 600 micron IS sieve.

Coarse aggregate:
20mm down size aggregates which is locally available are used.

Flyash:
Class F fly ash collected from local brick works is used and it is reduces Heat of Hydration, Class F Fly ash has 5% lime content.

Metakaolin:
It is obtained by the calcinations of pure or refined Kaolinite clay at a temperature between 650^0 c and 850^0 c, followed by grinding to achieve a fineness 700-900 m^2/kg.

Fig -1: Metakaolin

TABLE 1 Chemical composition of Metakaolin

Constituents	Percentage (%)
$SiO_2+Al_2O_{2+}Fe_2O_3$	96.88%
CaO	0.39%
MgO	0.08%
TiO_2	1.35%
K_2O	0.56%
Na_2O	0.56%
LOI	0.68%

Alccofine 1203:
It is a new generation, ultrafine, low calcium silicate product, manufactured in India. Alccofine has unique characteristics to enhance 'performance of concrete' in fresh and hardened stages.

Fig -2: Alccofine

TABLE 2.Chemical composition of Alccofine 1203

Chemical Analysis	Mass %
CaO	32-34
Al_2O_3	18-20
Fe_2O_3	1.8-2
SO_3	0.2-0.7
MgO	8-10
SiO_2	33-35 .00

Polypropylene Fibres**:**
These are the Materials used to avoid the cracks in concrete and to increase the tensile strength of concrete.

Fig -3: Polypropylene Fibres

Super Plasticizer:

The Super Plasticizer used is Dynamo SX 550 which is modified acrylic super plasticiser for concrete characterized by low W/C ratio and high mechanical strength.

Fig -4: Super Plasticizer

Curing Compound:
It is a liquid substance that is added as a surface coating on freshly installed concrete. It is used to reduce the loss of water or heat in order to create an ideal condition.

Fig -5: Curing Compound

2.4 METHODOLOGY

To Achieve the Objective of our Project we have adopted the methodology as follows,

1. Literature reviews
2. Problem Definition
3. Setting of Objectives
4. Basic Materials Testing
5. Mix Design
6. Material Quantity Calculation
7. Mould Preparation
8. Mixing & Casting
9. Demoulding
10. Applying the Curing Compound
11. Testing
12. Result Calculation

By following the above procedure we are able to get the expected results.

2.5 Mix Design

Stipulation for proportioning
Grade designation:M40
Type of cement: OPC 53 grade cement
Type of mineral admixture: Fly ash, Metakaolin and Alccofine
Max. nomial size of aggregates-20mm
Minimum cement content=320kg/m^3
Maximum water cement ratio=0.45
Chemical admixture type=Super plasticizer

2.6 TEST DATA FOR MATERIALS

- Cement used= OPC 53 grade conforming to IS 8112
- Specific gravity of cement= 3.15
- Fly ash= conforming to IS 3812(part 1)
- Specific gravity of fly ash= 2.6
- Specific gravity of,
- 1.course aggregate= 2.64
- 2.fine aggregate=2.60
- Water absorption
- course aggregate= 0.5%
- fine aggregate= 1.0%
- Free(surface) moisture
- coarse aggregate= nil(absorbed moisture also nil)
- fine aggregate= nil
- Sieve analysis
- course aggregate= 20mm passing
- fine aggregate= conforming to grading zone 2 of table 4 of IS 383

2.7 MIX DESIGN AND TEST RESULT

In our test, we had done three trails of test. Each trail is done by varying the metakaolin and alccofine and with constant amount of fly ash. For each trail the basic concrete test such as compression test , split tensile test and flexural test were done to determine the mechanical property of concrete.

Trail 01:-

In this trail 5% of Metakaolin and 5% Alccofine with 30% of fly ash is used. Test results are obtained as below,

Table -3: Mix design proportion

Sl.no	cement	Fine aggregate	Coarse aggregate	w/c ratio	admixture	fibre
1	1	1.798	2.32	0.4	3 %	1.5%

Table -4: Test result

	3days	7days	28days
Compression(N/mm2)	21.19	30	42
Split tensile (N/mm2)	1.93	3.4	4.7
Flexure (N/mm2)	2	5.23	7.05

Graph1:

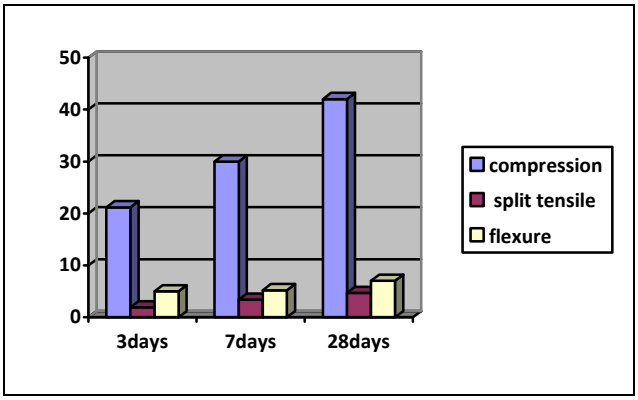

Chart -1: Test results for Trial-01

Trail 02:

In this trail 7% of metakaolin,3% of alccofine and 30% of fly ash are used.

Table -5: Mix design proportion

cement	Fine aggregate	Course aggregate	water	admixture	Fibers
1	1.803	2.33	0.4	3%	1.5%

Table -6: Test results

	3days	7days	28days
Compression(N/mm2)	21.40	32.5	49
Split tensile (N/mm2)	1.82	4.0	5.2
Flexure (N/mm2)	4.5	5.05	7.25

Graph2:

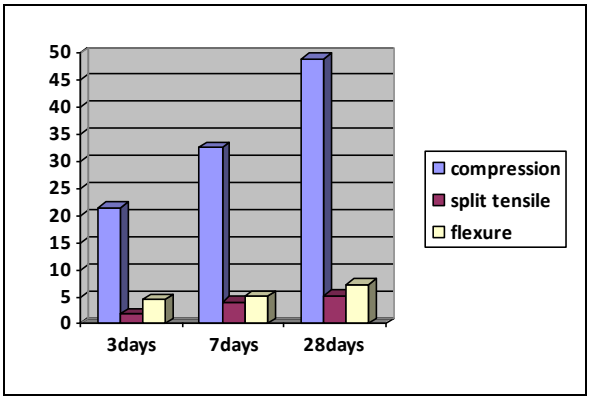

Chart -2: Test results for Trial-02

Trail 03:
In this trail 7%of alccofine, 3% of metakaolin and 30% of fly ash are used.

Table -7: Mix design proportion

cement	Fine aggregate	Course aggregate	water	Admixture	fibers
1	1.81	2.34	0.4	3%	1.5%

Table -8: Test results

	3days	7days	28days
Compression(N/mm2)	22.5	34.0	54.15
Split tensile (N/mm2)	1.9	4.2	5.6
Flexure (N/mm2)	3.0	4.5	6.4

Graph 3:

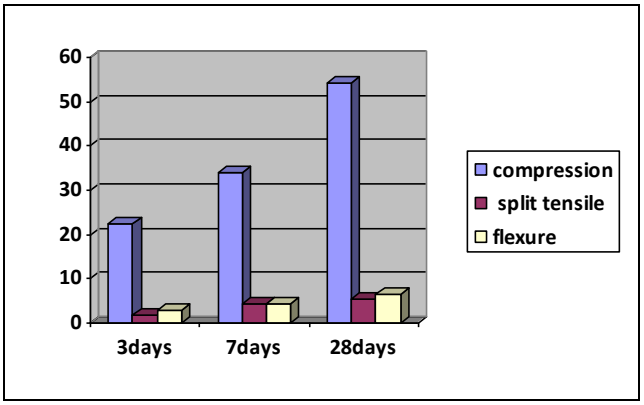

Chart -3: Test results for Trial-03

3. CONCLUSION

- All the concrete mixes made with different replacement levels of metakaolin and alccofine by weight of ordinary Portland cement showed higher compressive strength as compared to concrete mix made with ordinary Portland cement.
- We have got increase in flexural strength of concrete by replacement of cement by metakaolin and alccofine by 7% and of cement by metakaolin and alccofine by 7% and 3% respectively.
- Surface cracks are reduced as we used polypropylene fibres.
- Utilization of water has been reduced by using curing compound instead of water for curing.

3.1 FUTURE SCOPE

- The fly as which is replaced by 30% can be reduced and mix of metakolin and alccofine with different ratios can be tried.
- The study of strength properties for different ratios of metakaolin and alccofine by reducing the fly ash percentage can be made.
- The replacement of cement only by the combination of metakolin and alccofine can be experimented and their strength properties can be studied.
- As the use of water is reduced by using curing compound this can be applied in future when there is a scarcity of water.

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